

Solar Energy Activities at Discovery Park



Jerry Woodall

Epstein Distinguished Professor of ECE
National Medal of Technology Laureate

Presentation for the
Indiana Solar Energy Working Group Meeting
October 28, 2010

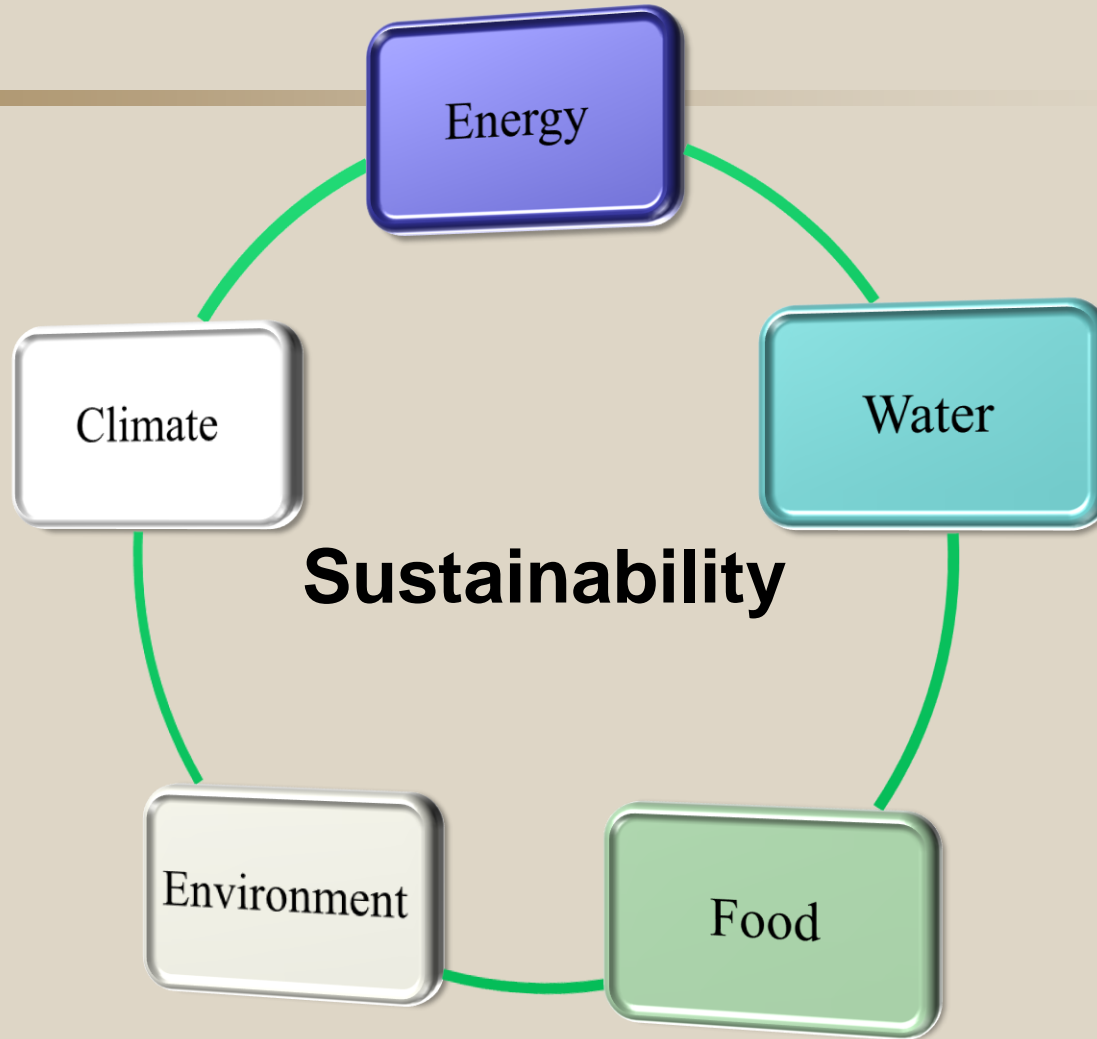
- ✓ Lilly Endowment support
- ✓ Institutional support
- ✓ Broad mission
- ✓ Synergism among centers

- Bindley Bioscience Center
- Birck Nanotechnology Center
- Burton D. Morgan Center for Entrepreneurship
- Discovery Learning Center
- **Global Sustainability at Purdue**
 - **Center for the Environment**
 - **Energy Center**
 - **Purdue Climate Change Research Center**
 - **Water Community**
 - **Food Security**
- Advanced Computational Center for Engineering and Sciences
 - Cyber Center
 - Computing Research Institute
 - Rosen Center for Advanced Computing
- Oncological Sciences Center
- Regenstrief Center for Healthcare Engineering





Global Sustainability Initiative



Also Synergistic and
Newly Launched

**Global Policy
Research Institute**

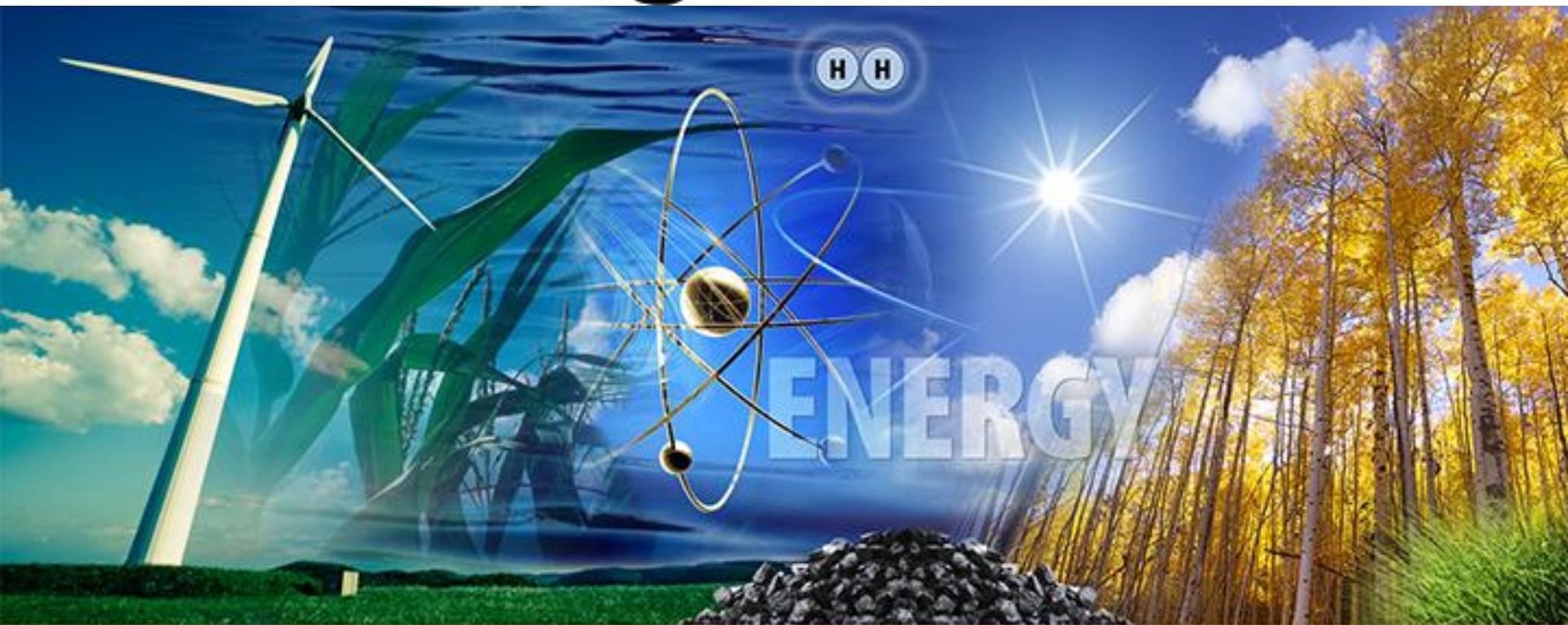


PURDUE UNIVERSITY

PURDUE EXTENSION
PURDUE UNIVERSITY

Klein Ileleji and Chad Martin

Discovery Park Energy Center

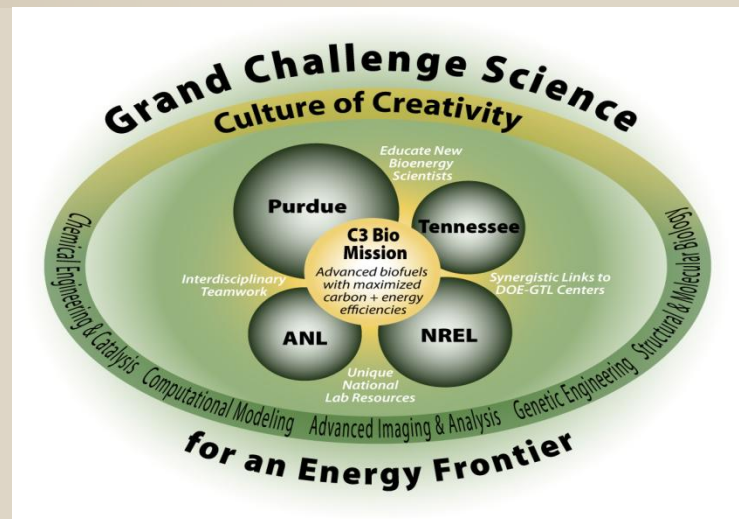


Discovery with delivery in energy sciences and engineering

The Energy Center at Discovery Park will facilitate high-impact, multidisciplinary projects in support of Purdue's vision to be one of the global leaders in energy

FOCUS AREAS

- Advanced Ground Vehicle Power
- Battery and Advanced Electrochemical Systems
- Bio; Coal; Hydrogen; Nuclear; Wind; Efficient Buildings; Solar
- Social, Economic and Policy Aspects of Energy



DOE/EFRC
Center for Catalytic Conversion of
Biomass to Biofuel

EXAMPLES

- *Biofuel Crop Research*
- *Optically Accessible Coal Gasifier for Synthetic Fuel*
- *Energy Efficiency & Environmental Impact in Buildings*



Solar Activities



- The Energy Center's work in solar energy takes parallel low-cost and high-efficiency (including modeling/ simulation) approaches to solar cell and electrode design. Faculty research focuses on both multi-junction, high-efficiency cells and thin film cells with reasonable efficiency but high affordability. The Solar Initiative Team has the fundamental knowledge and technical skill to enable a successful transition to economically and environmentally friendly solar power.
- An IGERT program is training next generation of energy scientists and engineers in multidisciplinary solar research.



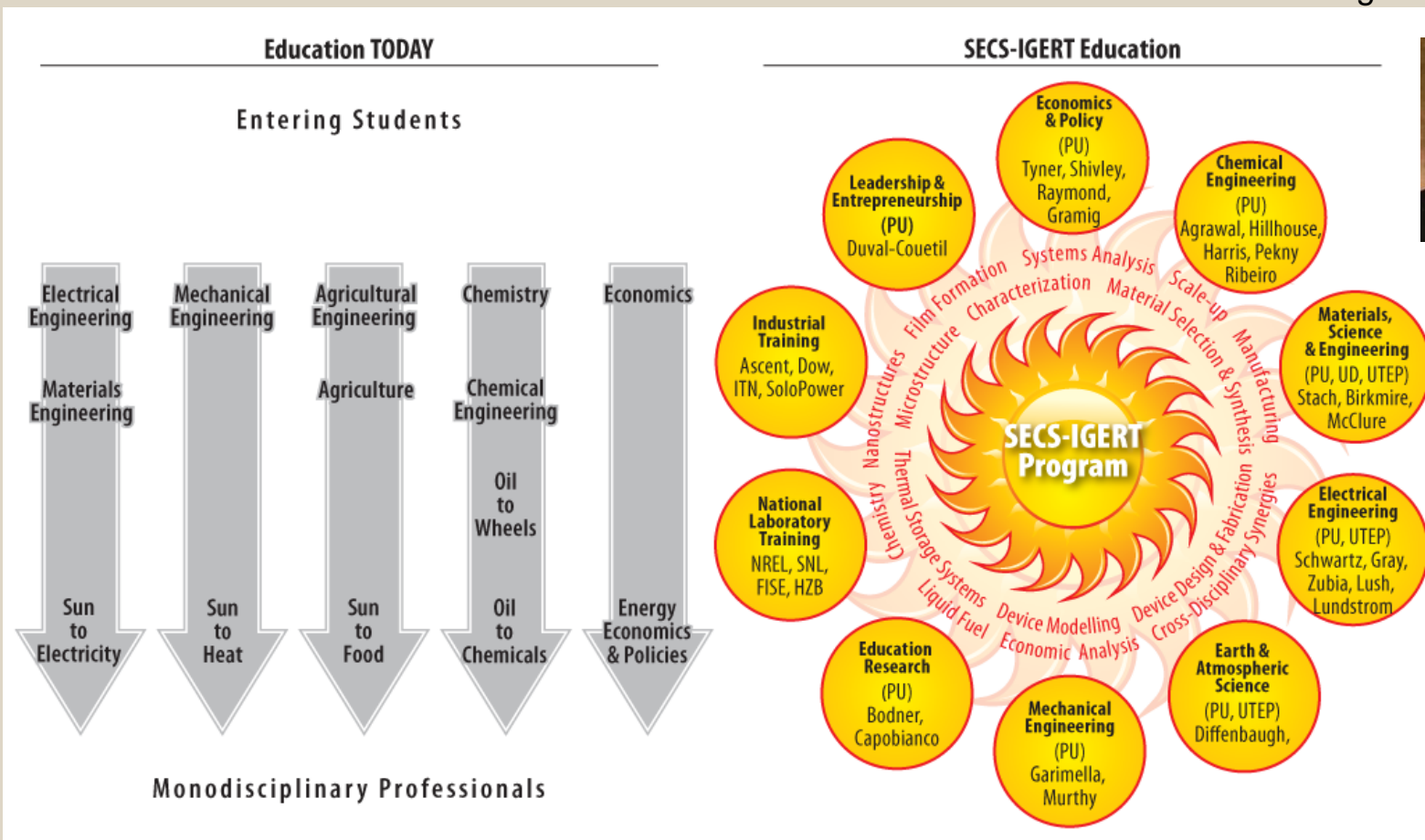
Large Programs: Solar IGERT

Training the Next Generation of Energy Scientists/Engineers in Multidisciplinary Research

Rakesh Agrawal, ChemE



Agrawal



Performance, Cost, Reliability, and Manufacturing Challenge of Solar Cells

Mark Lundstrom and Ashraf Alam, ECE

Partners

- Semiconductor Research Corporation
- DOE Energy Frontier Research Center
Brookhaven National Lab
- Carnegie Mellon University
- Northwestern
- IIT Bombay
- Applied Materials

Six Thrust Areas

•1) Process/Materials

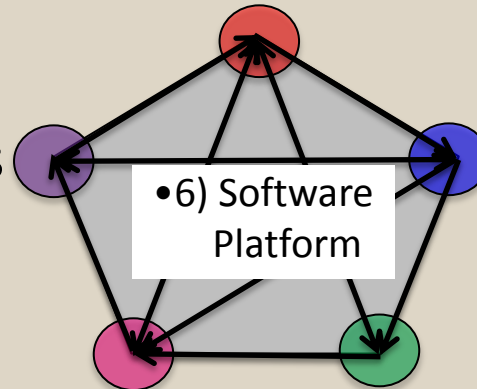


Lundstrom



Alam

•5) Systems



•2) Device

•4) Reliability

•3) Characterization

- End-to-end modeling of process/device/reliability/systems
- Approaches applicable to multiple materials
- Embedded in open source software platform



Modeling Spectrum Splitting Multi-Junction Solar Cells

- Part of a high efficiency, national-scale research project funded by DARPA.
- Develop detailed numerical models for the solar cells
- Develop models that are integrated into system models.
- Use cell models to guide solar cell design.



Richard Schwartz and Jeffrey Gray
School of Electrical and Computer
Engineering

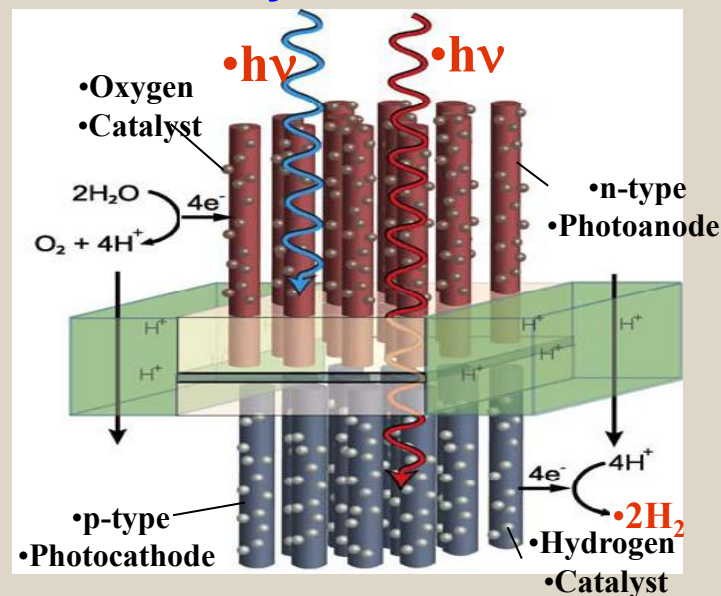


Constructing Optimum Electrode Architectures to Enhance Desired Properties and Stabilities of Electro/Photo-Chemical Devices – Kyoung Choi

- Control of semiconductor and catalyst morphologies to investigate morphology dependent photoelectrochemical properties.
- Site Selective Integration of catalysts on photoelectrode surfaces
- Studies on photoelectrode-catalyst Interactions

Construction of a High Performance Solar Water Splitting Cell

Hydrogen Production by Photolysis of Water



Kyoung Choi Group
Department of
Chemistry
**Conversion of
Solar Energy
to Form Chemical Fuels**

NSF Chemical Center for Innovation
Powering the Planet Production of Fuel from Sunlight



The Woodall Research Group:

IT'S ALL ABOUT ENERGY!

(energy storage, hydrogen and solar cells)

- Splitting water with aluminum rich alloys to make hydrogen on demand (ready now!)
- GaP as the top cell for “tandem stacks” for solar concentration system to achieve 50% conversion efficiency (near term)
- ZnSeGaAs for *all the cells in a tandem stack*. This lattice-matched system covers band gaps between 1.42 and 2.7 eV (up-stream)



Jerry Woodall
Electrical and Computer
Engineering

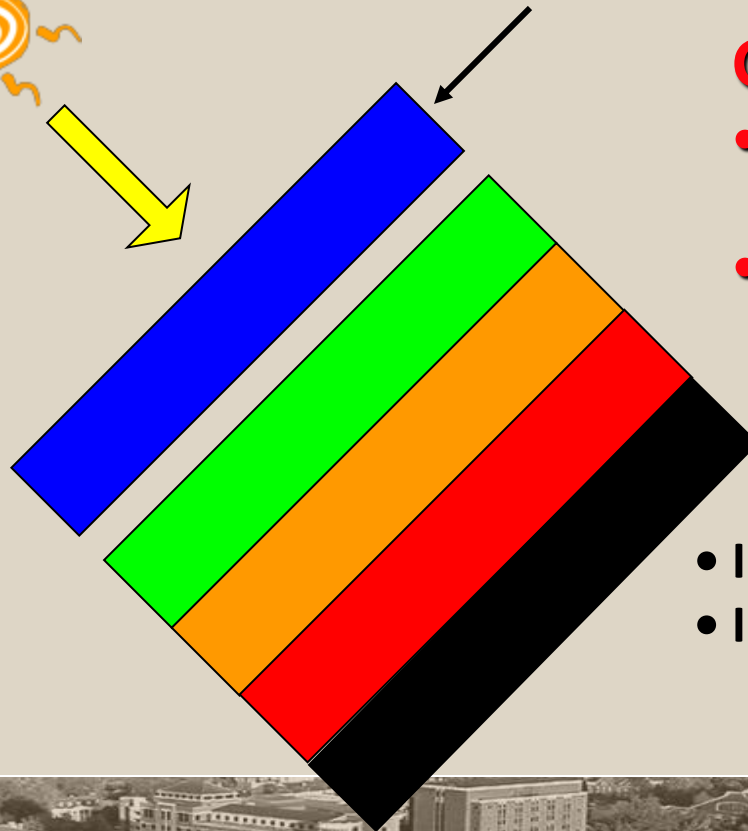


High Efficiency GaP Solar Cells: the Key to a 50% Multi-junction Solar Cell Concentrator System Efficiency

SOA: 4 different tandem cells gives 41+% efficiency with 300 x optical concentration

Rules:

- no dichroic mirrors
- stack is optically in series and electrically in parallel



High band gap top cell in multi-junction stack needed to achieve 50% efficiency)

GaP:

- could add 17% to SOA eff.,
- PU GaP: $V_{oc}=1.56\text{ V}$ (world's record)

- InGaN does not work
- InGaAlP V_{oc} only 1.5V



BULK ALUMINUM ALLOYS: A HIGH ENERGY DENSITY MATERIAL FOR SAFE ENERGY STORAGE, TRANSPORT, AND SPLITTING WATER TO MAKE HYDROGEN ON DEMAND:

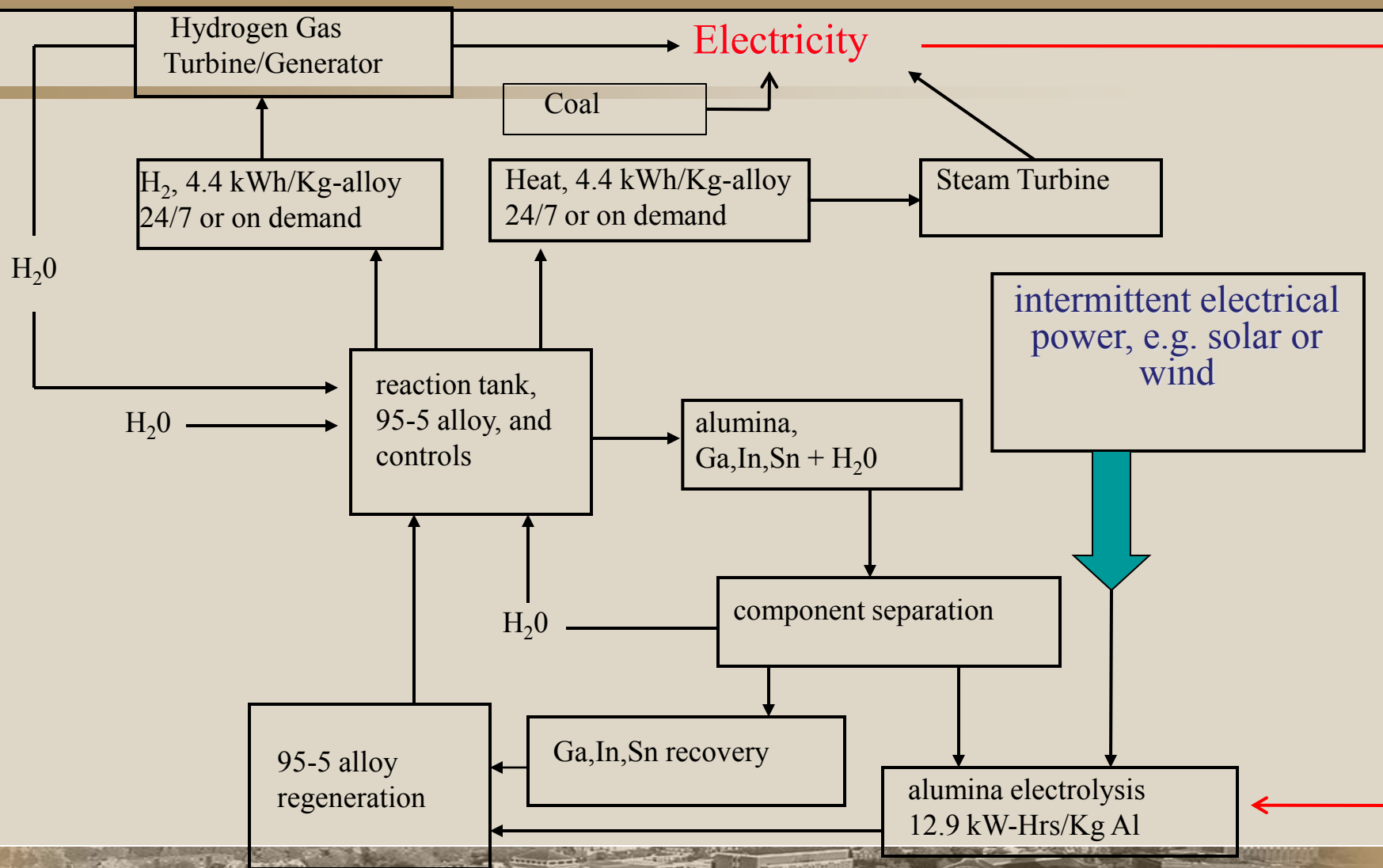


$3\text{H}_2 + 3/2\text{O}_2 \rightarrow 3\text{H}_2\text{O}$; we get back half the water
when we burn H_2 or use H_2 in a fuel cell



*Also salt water





Purdue student builds solar motorcycle, launches club to push more electric vehicle breakthroughs...

Solar Motorcycle

- Retrofitting and redesigning with \$2500 purchased in 1978 Suzuki motor cycle for \$50
- Cut down transportation cost
 - **24 miles per charge; 45 mph**



Purdue student Tony Danger Coiro invented a street-legal solar powered motorcycle. He's working to upgrade the penny per mile commuter vehicle into a 100 horsepower, 100 mph thriller.



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